

NATIONAL TRANSPORTATION SAFETY BOARD
Public Meeting of August 30, 2011
(Information subject to editing)

Pacific Gas and Electric Company
Natural Gas Transmission Pipeline Rupture and Fire
San Bruno, California
September 9, 2010

NTSB/PAR-11/01

This is a synopsis from the Safety Board's report and does not include the Board's rationale for the conclusions, probable cause, and safety recommendations. Safety Board staff is currently making final revisions to the report from which the attached conclusions and safety recommendations have been extracted. The final report and pertinent safety recommendation letters will be distributed to recommendation recipients as soon as possible. The attached information is subject to further review and editing.

EXECUTIVE SUMMARY

On September 9, 2010, about 6:11 p.m. Pacific daylight time, a 30-inch-diameter segment of an intrastate natural gas transmission pipeline known as Line 132, owned and operated by the Pacific Gas and Electric Company (PG&E), ruptured in a residential area in San Bruno, California. The rupture occurred at mile point 39.28 of Line 132, at the intersection of Earl Avenue and Glenview Drive. The rupture produced a crater about 72 feet long by 26 feet wide. The section of pipe that ruptured, which was about 28 feet long and weighed about 3,000 pounds, was found 100 feet south of the crater. PG&E estimated that 47.6 million standard cubic feet of natural gas was released. The released natural gas ignited, resulting in a fire that destroyed 38 homes and damaged 70. Eight people were killed, many were injured, and many more were evacuated from the area.

Investigation Synopsis

The National Transportation Safety Board's investigation found that the rupture of Line 132 was caused by a fracture that originated in the partially welded longitudinal seam of one of six short pipe sections, which are known in the industry as "pups." The fabrication of five of the pups in 1956 would not have met generally accepted industry quality control and welding standards then in effect, indicating that those standards were either overlooked or ignored. The weld defect in the failed pup would have been visible when it was installed. The investigation also determined that a sewer line installation in 2008 near the rupture did not damage the defective pipe.

The rupture occurred at 6:11 p.m.; almost immediately, the escaping gas from the ruptured pipe ignited and created an inferno. The first 911 call was received within seconds. Officers from the San Bruno Police Department arrived on scene about 6:12 p.m. Firefighters at

the San Bruno Fire Department heard and saw the explosion from their station, which was about 300 yards from the rupture site. Firefighters were on scene about 6:13 p.m. More than 900 emergency responders from the city of San Bruno and surrounding jurisdictions executed a coordinated emergency response, which included defensive operations, search and evacuation, and medical operations. Once the flow of natural gas was interrupted, firefighting operations continued for 2 days. Hence, the emergency response by the city of San Bruno was prompt and appropriate.

However, PG&E took 95 minutes to stop the flow of gas and to isolate the rupture site—a response time that was excessively long and contributed to the extent and severity of property damage and increased the life-threatening risks to the residents and emergency responders. The National Transportation Safety Board found that PG&E lacks a detailed and comprehensive procedure for responding to large-scale emergencies such as a transmission pipeline break, including a defined command structure that clearly assigns a single point of leadership and allocates specific duties to supervisory control and data acquisition staff and other involved employees. PG&E’s supervisory control and data acquisition system limitations caused delays in pinpointing the location of the break. The use of either automatic shutoff valves or remote control valves would have reduced the amount of time taken to stop the flow of gas.

PG&E’s pipeline integrity management program, which should have ensured the safety of the system, was deficient and ineffective because it --

- Was based on incomplete and inaccurate pipeline information.
- Did not consider the design and materials contribution to the risk of a pipeline failure.
- Failed to consider the presence of previously identified welded seam cracks as part of its risk assessment.
- Resulted in the selection of an examination method that could not detect welded seam defects.
- Led to internal assessments of the program that were superficial and resulted in no improvements.

Several deficiencies revealed by the National Transportation Safety Board investigation, such as PG&E’s poor quality control during the pipe installation and inadequate emergency response, were factors in the 2008 explosion of a PG&E gas pipeline in Rancho Cordova, California. (See *Explosion, Release, and Ignition of Natural Gas, Rancho Cordova, California, December 24, 2008*, Pipeline Accident Brief NTSB/PAB-10/01 (Washington, DC: National Transportation Safety Board, 2010)). This 2008 accident involved the inappropriate installation of a pipe that was not intended for operational use and did not meet applicable pipe specifications. PG&E’s response to that event was inadequate; PG&E initially dispatched an unqualified person to the emergency, causing an unnecessary delay in dispatching a properly trained and equipped technician. The National Transportation Safety Board concluded that PG&E’s multiple, recurring deficiencies are evidence of a systemic problem.

The investigation also determined that the California Public Utilities Commission, the pipeline safety regulator within the state of California, failed to detect the inadequacies in PG&E’s integrity management program and that the Pipeline and Hazardous Materials Safety Administration integrity management inspection protocols need improvement. Because the Pipeline and Hazardous Materials Safety Administration has not incorporated the use of effective

and meaningful metrics as part of its guidance for performance-based management pipeline safety programs, its oversight of state public utility commissions regulating gas transmission and hazardous liquid pipelines could be improved. Without effective and meaningful metrics in performance-based pipeline safety management programs, neither PG&E nor the California Public Utilities Commission was able to effectively evaluate or assess PG&E's pipeline system.

FINDINGS

1. The following were not factors in this accident: seismic activity, corrosion, direct third-party damage, or drug use by the workers at the Milpitas Terminal.
2. The accident pipe comprising the pups did not conform to PG&E or other known specifications for pipe and was fabricated at an undetermined facility to no known specification.
3. The accident pipe would not have met generally accepted industry quality control and welding standards in 1956, indicating that those standards were overlooked or ignored.
4. PG&E's inadequate quality control during the 1956 relocation project led to the installation and commissioning of a defective pipe that remained undetected until the accident, 54 years later.
5. The fracture of Line 132 Segment 180 originated in the partially welded longitudinal seam of pup 1, which was progressively weakened due to ductile crack growth and fatigue crack growth.
6. The combination of the size and shape of the weld defect significantly reduced the strength of the pup 1 longitudinal seam, making it susceptible to unstable crack growth under internal gas pressure.
7. The 2008 sewer line installation did not damage the defective pipe that later ruptured.
8. The internal line pressure preceding the rupture did not exceed the PG&E maximum allowable operating pressure for Line 132 and would not have posed a safety hazard for a properly constructed pipe.
9. Had a properly prepared contingency plan for the Milpitas Terminal electrical work been in place and been executed, the loss of pressure control could have been anticipated and planned for, thereby minimizing or avoiding the pressure deviations.
10. PG&E lacked detailed and comprehensive procedures for responding to a large-scale emergency such as a transmission line break, including a defined command structure that clearly assigns a single point of leadership and allocates specific duties to supervisory control and data acquisition staff and other involved employees.

11. PG&E's supervisory control and data acquisition system limitations contributed to the delay in recognizing that there had been a transmission line break and quickly pinpointing its location.
12. The 95 minutes that PG&E took to stop the flow of gas by isolating the rupture site was excessive.
13. Use of automatic shutoff valves or remote control valves along the entire length of Line 132 would have significantly reduced the amount of time taken to stop the flow of gas and to isolate the rupture.
14. Considering the challenges of the prolonged fire fueled by natural gas, the emergency response was well coordinated and effectively managed by local responders.
15. The 6-hour delay before ordering drug and alcohol testing, the commencement of alcohol testing at the Milpitas Terminal 1 hour after it was no longer permitted, the failure to properly record an explanation for the delay, and the failure to conduct drug or alcohol testing on the supervisory control and data acquisition center staff all demonstrate that the PG&E postaccident toxicological program was ineffective.
16. If the grandfathering of older pipelines had not been permitted since 1961 by the California Public Utilities Commission and since 1970 by the U.S. Department of Transportation, Line 132 would have undergone a hydrostatic pressure test that would likely have exposed the defective pipe that led to this accident.
17. There is no safety justification for the grandfather clause exempting pre-1970 pipelines from the requirement for postconstruction hydrostatic pressure testing.
18. The premise in Title 49 *Code of Federal Regulations* Part 192 of the Federal pipeline safety regulations that manufacturing- and construction-related defects can be considered stable even when a gas pipeline has not been subjected to a pressure test of at least 1.25 times the maximum allowable operating pressure is not supported by scientific studies.
19. The PG&E gas transmission integrity management program was deficient and ineffective.
20. PG&E's public awareness program self-evaluation was ineffective at identifying and correcting deficiencies.
21. The deficiencies identified during this investigation are indicative of an organizational accident.
22. The multiple and recurring deficiencies in PG&E operational practices indicate a systemic problem.

23. Because in-line inspection technology is not available for use in all currently operating gas transmission pipeline systems, operators do not have the benefit of a uniquely effective assessment tool to identify and assess the threat from critical defects in their pipelines.
24. The Pipeline and Hazardous Materials Safety Administration integrity management inspection protocols are inadequate.
25. Because PG&E, as the operator of its pipeline system, and the California Public Utilities Commission, as the pipeline safety regulator within the state of California, have not incorporated the use of effective and meaningful metrics as part of their performance-based pipeline safety management programs, neither PG&E nor the California Public Utilities Commission is able to effectively evaluate or assess the integrity of PG&E's pipeline system.
26. Because the Pipeline and Hazardous Materials Safety Administration has not incorporated the use of effective and meaningful metrics as part of its guidance for effective performance-based pipeline safety management programs, its oversight of state public utility commissions regulating gas transmission and hazardous liquid pipelines needs improvement.
27. The ineffective enforcement posture of the California Public Utilities Commission permitted PG&E's organizational failures to continue over many years.
28. The Pipeline and Hazardous Materials Safety Administration's enforcement program and its monitoring of state oversight programs have been weak and have resulted in lack of effective Federal oversight and state oversight exercised by the California Public Utilities Commission.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of the accident was the Pacific Gas and Electric Company's (PG&E) (1) inadequate quality assurance and quality control in 1956 during its Line 132 relocation project, which allowed the installation of a substandard and poorly welded pipe section with a visible seam weld flaw that, over time grew to a critical size, causing the pipeline to rupture during a pressure increase stemming from poorly planned electrical work at the Milpitas Terminal; and (2) inadequate pipeline integrity management program, which failed to detect and repair or remove the defective pipe section.

Contributing to the accident were the California Public Utility Commission's (CPUC) and the U.S. Department of Transportation's exemptions of existing pipelines from the regulatory requirement for pressure testing, which likely would have detected the installation defects. Also contributing to the accident was the CPUC's failure to detect the inadequacies of PG&E's pipeline integrity management program.

Contributing to the severity of the accident were the lack of either automatic shutoff valves or remote control valves on the line and PG&E's flawed emergency response procedures and delay in isolating the rupture to stop the flow of gas.

RECOMMENDATIONS

The National Transportation Safety Board makes new recommendations to the U.S. Secretary of Transportation, the Pipeline and Hazardous Materials Safety Administration, the governor of the state of California, the California Public Utilities Commission, and the Pacific Gas and Electric Company.

The National Transportation Safety Board previously issued recommendations to the Pipeline and Hazardous Materials Safety Administration, the California Public Utilities Commission, and the Pacific Gas and Electric Company as a result of this accident.

New Recommendations

To the U.S. Secretary of Transportation:

1. Conduct an audit to assess the effectiveness of the Pipeline and Hazardous Materials Safety Administration's oversight of performance-based safety programs. This audit should address the (1) need to expand the program's use of meaningful metrics; (2) adequacy of its inspection protocols for ensuring the completeness and accuracy of pipeline operators' integrity management program data; (3) adequacy of its inspection protocols for ensuring the incorporation of an operator's leak, failure, and incident data in evaluations of the operator's risk model; and (4) benefits of establishing performance goals for pipeline operators.
2. Include in the audit conducted pursuant to Recommendation [1] a review of the Pipeline and Hazardous Materials Safety Administration's enforcement policies and procedures, including, specifically, the standard of review for compliance with performance-based regulations.
3. Conduct an audit of the Pipeline and Hazardous Materials Safety Administration's state pipeline safety program certification program to assess and ensure state pipeline safety programs and Federal pipeline safety grants are used effectively to conduct oversight of intrastate pipeline operations, including an evaluation of state inspection and enforcement activities.
4. Ensure that the Pipeline and Hazardous Materials Safety Administration amends the certification program, as appropriate, to comply with the findings of the audit recommended in Recommendation [3].

To the Pipeline and Hazardous Materials Safety Administration:

5. Require operators of natural gas transmission and distribution pipelines and hazardous liquid pipelines to provide system-specific information about their

pipeline systems to the emergency response agencies of the communities and jurisdictions in which those pipelines are located. This information should include pipe diameter, operating pressure, product transported, and potential impact radius. [Supersedes Recommendation P-11-1]

6. Require operators of natural gas transmission and distribution pipelines and hazardous liquid pipelines to ensure that their control room operators immediately and directly notify the 911 emergency call center(s) for the communities and jurisdictions in which those pipelines are located when a possible rupture of any pipeline is indicated. [Supersedes Recommendation P-11-2]
7. Require that all operators of natural gas transmission and distribution pipelines equip their supervisory control and data acquisition systems with tools to assist in recognizing and pinpointing the location of leaks, including line breaks; such tools could include a real-time leak detection system and appropriately spaced flow and pressure transmitters along covered transmission lines.
8. Amend Title 49 *Code of Federal Regulations* 192.935(c) to directly require that automatic shutoff valves or remote control valves in high consequence areas and in class 3 and 4 locations be installed and spaced at intervals that consider the factors listed in that regulation.
9. Amend 49 CFR 199.105 and 49 CFR 199.225 to eliminate operator discretion with regard to testing of covered employees. The revised language should require drug and alcohol testing of each employee whose performance either contributed to the accident or cannot be completely discounted as a contributing factor to the accident.
10. Issue immediate guidance clarifying the need to conduct postaccident drug and alcohol testing of all potentially involved personnel despite uncertainty about the circumstances of the accident.
11. Amend Title 49 *Code of Federal Regulations* 192.619 to delete the grandfather clause and require that all gas transmission pipelines constructed before 1970 be subjected to a hydrostatic pressure test that incorporates a spike test.
12. Amend Title 49 *Code of Federal Regulations* Part 192 of the Federal pipeline safety regulations so that manufacturing- and construction-related defects can only be considered stable if a gas pipeline has been subjected to a postconstruction hydrostatic pressure test of at least 1.25 times the maximum allowable operating pressure.
13. Assist the California Public Utilities Commission in conducting the comprehensive audit recommended in Safety Recommendation [19].

14. Require that all natural gas transmission pipelines be configured so as to accommodate in-line inspection tools, with priority given to older pipelines.
15. Revise your integrity management inspection protocol to (1) incorporate a review of meaningful metrics; (2) require auditors to verify that the operator has a procedure in place for ensuring the completeness and accuracy of underlying information; (3) require auditors to review all integrity management performance measures reported to the Pipeline and Hazardous Materials Safety Administration and compare the leak, failure, and incident measures to the operator's risk model; and (4) require setting performance goals for pipeline operators at each audit and follow up on those goals at subsequent audits.
16. (1) Develop and implement standards for integrity management and other performance-based safety programs that require operators of all types of pipeline systems to regularly assess the effectiveness of their programs using clear and meaningful metrics, and to identify and then correct deficiencies; and (2) make those metrics available in a centralized database.
17. Work with state public utility commissions to (1) implement oversight programs that employ meaningful metrics to assess the effectiveness of their oversight programs and make those metrics available in a centralized database, and (2) identify and then correct deficiencies in those programs.

To the Governor of the State of California:

18. Expeditiously evaluate the authority and ability of the pipeline safety division within the California Public Utilities Commission to effectively enforce state pipeline safety regulations, and, based on the results of this evaluation, grant the pipeline safety division within the California Public Utilities Commission the direct authority, including the assessment of fines and penalties, to correct noncompliance by state regulated pipeline operators.

To the California Public Utilities Commission:

19. With assistance from the Pipeline and Hazardous Materials Safety Administration, conduct a comprehensive audit of all aspects of Pacific Gas and Electric Company operations, including control room operations, emergency planning, record-keeping, performance-based risk and integrity management programs, and public awareness programs.
20. Require the Pacific Gas and Electric Company to correct all deficiencies identified as a result of the San Bruno, California, accident investigation, as well as any additional deficiencies identified through the comprehensive audit recommended in Safety Recommendation [19], and verify that all corrective actions are completed.

To the Pacific Gas and Electric Company:

21. Revise your work clearance procedures to include requirements for identifying the likelihood and consequence of failure associated with the planned work and for developing contingency plans.
22. Establish a comprehensive emergency response procedure for responding to large-scale emergencies on transmission lines; the procedure should (1) identify a single person to assume command and designate specific duties for supervisory control and data acquisition staff and all other potentially involved company employees; (2) include the development and use of troubleshooting protocols and checklists; and (3) include a requirement for periodic tests and/or drills to demonstrate the procedure can be effectively implemented.
23. Equip your supervisory control and data acquisition system with tools to assist in recognizing and pinpointing the location of leaks, including line breaks; such tools could include a real-time leak detection system and appropriately spaced flow and pressure transmitters along covered transmission lines.
24. Expedite the installation of automatic shutoff valves and remote control valves on transmission lines in high consequence areas and in class 3 and 4 locations, and space them at intervals that consider the factors listed in Title 49 *Code of Federal Regulations* 192.935(c).
25. Revise your postaccident toxicological testing program to ensure that testing is timely and complete.
26. Assess every aspect of your integrity management program, paying particular attention to the areas identified in this investigation, and implement a revised program that includes, at a minimum, (1) a revised risk model to reflect the Pacific Gas and Electric Company's actual recent experience data on leaks, failures, and incidents; (2) consideration of all defect and leak data for the life of each pipeline, including its construction, in risk analysis for similar or related segments to ensure that all applicable threats are adequately addressed; (3) a revised risk analysis methodology to ensure that assessment methods are selected for each pipeline segment that address all applicable integrity threats, with particular emphasis on design/material and construction threats; and (4) an improved self-assessment that adequately measures whether the program is effectively assessing and evaluating the integrity of each covered pipeline segment.
27. Conduct threat assessments using the revised risk analysis methodology incorporated in your integrity management program, as recommended in Safety Recommendation [26], and report the results of those assessments to the California Public Utilities Commission and the Pipeline and Hazardous Materials Safety Administration.

28. Develop, and incorporate into your public awareness program, written performance measurements and guidelines for evaluating the plan and for continuous program improvement.

To the American Gas Association and the Interstate Natural Gas Association of America:

29. Report to the National Transportation Safety Board on your progress to develop and introduce advanced inline inspection platforms for use in gas transmission pipelines not currently accessible to existing inline inspection platforms, including a timeline for implementation of these advanced platforms.

Previously Issued Recommendations

To the Pipeline and Hazardous Materials Safety Administration:

Through appropriate and expeditious means such as advisory bulletins and posting on your website, immediately inform the pipeline industry of the circumstances leading up to and the consequences of the September 9, 2010, pipeline rupture in San Bruno, California, and the National Transportation Safety Board's urgent safety recommendations to Pacific Gas and Electric Company so that pipeline operators can proactively implement corrective measures as appropriate for their pipeline systems. (P-10-1) (Urgent)

Issue guidance to operators of natural gas transmission and distribution pipelines and hazardous liquid pipelines regarding the importance of sharing system-specific information, including pipe diameter, operating pressure, product transported, and potential impact radius, about their pipeline systems with the emergency response agencies of the communities and jurisdictions in which those pipelines are located. (P-11-1)

Issue guidance to operators of natural gas transmission and distribution pipelines and hazardous liquid pipelines regarding the importance of control room operators immediately and directly notifying the 911 emergency call center(s) for the communities and jurisdictions in which those pipelines are located when a possible rupture of any pipeline is indicated. (P-11-2)

To the California Public Utilities Commission:

Develop an implementation schedule for the requirements of Safety Recommendation P-10-2 (Urgent) to Pacific Gas and Electric Company (PG&E) and ensure, through adequate oversight, that PG&E has aggressively and diligently searched documents and records relating to pipeline system components, such as pipe segments, valves, fittings, and weld seams, for PG&E natural gas transmission lines in class 3 and class 4 locations and class 1 and class 2 high consequence areas that have not had a maximum allowable operating

pressure established through prior hydrostatic testing as outlined in Safety Recommendation P-10-2 (Urgent) to PG&E. These records should be traceable, verifiable, and complete; should meet your regulatory intent and requirements; and should have been considered in determining maximum allowable operating pressures for PG&E pipelines. (P-10-5) (Urgent)

If such a document and records search cannot be satisfactorily completed, provide oversight to any spike and hydrostatic tests that Pacific Gas and Electric Company is required to perform according to Safety Recommendation P-10-4. (P-10-6) (Urgent)

Through appropriate and expeditious means, including posting on your website, immediately inform California intrastate natural gas transmission operators of the circumstances leading up to and the consequences of the September 9, 2010, pipeline rupture in San Bruno, California, and the National Transportation Safety Board's urgent safety recommendations to Pacific Gas and Electric Company so that pipeline operators can proactively implement corrective measures as appropriate for their pipeline systems. (P-10-7) (Urgent)

To the Pacific Gas and Electric Company:

Aggressively and diligently search for all as-built drawings, alignment sheets, and specifications, and all design, construction, inspection, testing, maintenance, and other related records, including those records in locations controlled by personnel or firms other than Pacific Gas and Electric Company, relating to pipeline system components, such as pipe segments, valves, fittings, and weld seams for Pacific Gas and Electric Company natural gas transmission lines in class 3 and class 4¹ locations and class 1 and class 2² high consequence areas³ that have not had a maximum allowable operating pressure established through prior hydrostatic testing. These records should be traceable, verifiable, and complete. (P-10-2) (Urgent)

Use the traceable, verifiable, and complete records located by implementation of Safety Recommendation P-10-2 (Urgent) to determine the valid maximum allowable operating pressure, based on the weakest section of the pipeline or component to ensure safe operation, of Pacific Gas and Electric Company natural gas transmission lines in class 3 and class 4 locations and class 1 and class 2 high consequence areas that have not had a maximum allowable operating pressure established through prior hydrostatic testing. (P-10-3) (Urgent)

¹ Class 3 refers to any location unit that has 46 or more buildings intended for human occupancy. Class 4 refers to any class location unit where buildings with four or more stories above ground are prevalent.

² Class 1 refers to an offshore area or any class location unit that has 10 or fewer buildings intended for human occupancy. A class 2 location is any class location unit that has more than 10 but fewer than 46 buildings intended for human occupancy.

³ A high consequence area is any class 3 or 4 location or any area where a potential impact radius of 660 feet would contain more than 20 buildings intended for human occupancy.

If you are unable to comply with Safety Recommendations P-10-2 (Urgent) and P-10-3 (Urgent) to accurately determine the maximum allowable operating pressure of Pacific Gas and Electric Company natural gas transmission lines in class 3 and class 4 locations and class 1 and class 2 high consequence areas that have not had a maximum allowable operating pressure established through prior hydrostatic testing, determine the maximum allowable operating pressure with a spike test followed by a hydrostatic pressure test. (P-10-4)

Require your control room operators to notify, immediately and directly, the 911 emergency call center(s) for the communities and jurisdictions in which your transmission and/or distribution pipelines are located, when a possible rupture of any pipeline is indicated. (P-11-3)